Source Control Evaluation
Operable Unit 1
Swan Island Upland Facility
Portland, Oregon

Prepared for:
Port of Portland

February 20, 2013
1115-06

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A Division of Apex Companies, LLC
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1.0 Introduction

1.1 Purpose

This report presents the results of a Source Control Evaluation (SCE) related to historical operations for operable unit 1 (OU1) of the Swan Island Upland Facility (SIUF), located at 5225 N Channel Avenue in Portland, Oregon. Figure 1 shows the location of the SIUF, and Figure 2 shows the boundaries of OU1. This SCE was performed in response to a request by the Oregon Department of Environmental Quality (DEQ) to identify, evaluate, and control sources of contamination that may reach the Willamette River consistent with the DEQ-EPA Portland Harbor Joint Source Control Strategy (JSCS; DEQ, 2005).

The Port of Portland (Port) is performing a Remedial Investigation/Feasibility Study (RI/FS) for the SIUF. The SIUF was previously referred to as the Swan Island Portland Ship Yard and identified by the DEQ as Environmental Cleanup Site Information (ECSI) site 271. The RI is being performed in accordance with the November 2, 2000 RI/FS Work Plan for the Portland Shipyard (RI/FS Work Plan; Bridgewater Group, 2000).

1.2 Regulatory Framework

This work is being conducted under an agreement between the Port and DEQ – Voluntary Agreement for Remedial Investigation, Source Control Measures, and Feasibility Study – dated July 24, 2006 (Agreement). For the purposes of the work conducted under the Agreement, the SIUF has been divided into four OUs designated as follows.

- OU1 – Approximately 57 acres of upland property owned by Shipyard Commerce Center LLC (formerly Cascade General), and operated as the Vigor Marine (Vigor) Ship Repair Yard and formerly known as the Portland Shipyard (PSY).
- OU2 – Approximately 24 acres of upland property owned by the Port south of N Channel Avenue, formerly referred to as the N Channel Avenue Fabrication site.
- OU3 – Approximately 2.5 acres of upland property owned by the Port on N Lagoon Avenue that includes the property at 5420 N Lagoon Avenue and the adjacent property to the north that provides access to Berths 308 and 309.
- OU4 – Approximately 7.8 acres of upland property between OU1 and OU2. Until 2008, OU4 was part of OU2, but was designated a separate OU to facilitate the sale of the property from the Port to Shipyard Commerce Center LLC.

Figure 2 shows the locations of the OUs.

Consistent with the Agreement, the SIUF does not include: (1) adjacent sediments, submerged lands, and submersible lands up to the ordinary line of high water (OLHW) of the Willamette River; (2) the remaining portions of the Swan Island peninsula; (3) dry docks owned, operated, and maintained by Vigor; (4) storm water conveyance systems owned, operated, and maintained by Vigor under National Pollutant Discharge Elimination System (NPDES) General Permit 1200-Z; (5) waste discharges permitted under NPDES Permit No. 101393, including treated ballast water from the ballast water treatment plant (BWTP), treated dry dock storm water and process wastewater, and untreated non-contact cooling water from the dry docks ballast water treatment plant; (6) the Port's Berth 311 upland site; and (7) any other activities or operations over which the Port has no control associated with Vigor or its subcontractors.

1.3 Source Control Evaluation Objective

The objectives of the SCE for OU1 are to: (1) identify potential sources of contamination; (2) evaluate the potential sources identified; and (3) if necessary, recommend controls of potential sources of contamination that may adversely impact the Willamette River.

1.4 Source Control Evaluation Scope

The Port does not own or operate OU1. Therefore, the scope of this SCE is limited to evaluation of historical releases that have the potential to migrate to the Willamette River. The scope specifically excludes storm water and overwater activities.

1.5 Report Organization

This report is divided into five additional sections. Section 2 discusses background information on OU1, including site use, riverbank sampling, groundwater investigations, and available data for sediment near OU1. Soil and groundwater data are summarized in tables in Appendices A through C. In Section 3, potentially complete migration pathways from the Facility to the river are identified. Section 4 presents an evaluation of the potential for erosion of the riverbank. Section 5 contains a screening evaluation of soil and groundwater data. For each potentially complete pathway to the river and media containing chemicals above screening levels, Section 6 presents a weight-of-evidence evaluation of the potential for contaminant transport to the river. Results of the SCE are summarized in Section 7.

2.0 Site Background

2.1 Site Description

Figure 2 shows the layout of OU1. The property covers approximately 57 acres on the northwest end of Swan Island. OU1 consists of the upland property currently owned by Vigor, referred to as the Cascade General Ship Repair Yard (CGSRY), and formerly known as the PSY.

Except for the slope along the riverbank (between top of bank and the OLHW), OU1 is relatively flat. Land surface elevations generally range between 30 and 34 feet (NGVD 29 with the 1947 adjustment) in the upland areas (Hahn and Associates, 2002). This area is further described in Section 2.3.

In general, where not covered with structures, the riverbank is characterized by engineered slopes covered with rip rap on the lower portions and vegetation on the upper portions. Structures include concrete wharf, steel bulkheads, and wooden retaining walls. Some areas of exposed soil are present. Photographs showing the typical riverbank condition are included in Appendix D.

Shallow groundwater occurs under water table conditions at the SIUF. The depth to groundwater at OU1 ranges from approximately 18 to 31 feet below ground surface (bgs; Bridgewater Group, 2008; see Table 1 in Appendix C). Shallow groundwater is recharged by the infiltration of precipitation that falls on Swan Island. Groundwater monitoring performed as part of the SIUF RI determined that groundwater beneath Swan Island flows outward from the center of the island toward surrounding water bodies. As OU1 is located at the northwest end of Swan Island, next to the Willamette River and Swan Island Lagoon, groundwater beneath OU1 is expected to flow toward and discharge to the Willamette River and the lagoon.

2.2 Historical Site Use

OU1 is a portion of the SIUF. The SIUF was previously referred to by DEQ as the “Swan Island Portland Ship Yard” and identified by DEQ as ECSI Site 271. Figure 1 shows the location of the SIUF. Figure 2 shows the boundary of OU1. Specific details of site history are discussed in the Draft Supplemental Preliminary Assessment (Ash Creek, 2006) and RI/FS Work Plan (Bridgewater Group, 2000).

The Port acquired Swan Island in 1922. At that time, the main channel of the river was on the easterly side of the island, between the island and what is now Mocks Landing. Following the purchase, the navigation channel was relocated to the west side of the island. Shore areas on the island were excavated to form a new and wider channel to the southwest. The island’s surface elevation was raised with fill from excavation and dredging activities. A causeway was constructed to the southeast to connect the island to the shore, which created Swan Island Lagoon. Swan Island was then developed and served as the municipal airport for Portland from 1931 until it was relocated to the current location of Portland International Airport in 1940. The airport was used by private aviation tenants until 1942.

In 1942, the U.S. Maritime Commission entered into an agreement to lease approximately 250 acres of Swan Island from the Port. The Maritime Commission then contracted with Kaiser Company for the construction and operation of a shipbuilding yard on the island. Kaiser operated the shipyard until 1945. From 1945 until 1949, the shipyard was sub-leased by the United States to various tenants. In 1949, the Port purchased the shipyard assets from the United States.

Beginning in 1950, the Port managed the Swan Island Ship Repair Yard, later known as the PSY, as a multi-user facility. Through 1995, the Port expanded the PSY capabilities including addition of dry docks; construction of the first BWTP in 1973; development of berths along the Willamette River; and construction of a new BWTP in 1979. During the time of the Port's ownership, it offered the facilities for ship repair by tariff, contracted with various companies to provide ship repair services, and leased space to a number of tenants who supported ship repair activities and performed other industrial operations.

In 1996, the Port entered into an operating agreement with Cascade General. While the Port retained ownership of the shipyard, operations were transferred to Cascade General, who took responsibility for contractor/tenant management. The construction of a plant to treat storm water from the dry docks (i.e., water generated from raising the dry docks) was completed in 1997. In 2000, the Port sold the portion of the shipyard that is defined in the Agreement as OU1 to Shipyard Commerce Center LLC (currently a subsidiary of Vigor Industrial, LLC).

2.3 Current Site Use

The CGSRY is used for full-service ship repair including ship conversions, overhauls, maintenance programs, damage repair, and equipment repair for privately owned and government vessels. Based on Vigor Industrial's promotional materials, the CGSRY includes the following:

- 60-acre yard on the Willamette River
- 3 dry docks with dimensions of up to 660 feet long and 140 feet wide
- Repair and lay-up berths totaling 9,665 feet ranging from 370 feet to 1,110 feet and a maximum draft of 40 feet
- 17 Whirley cranes with a tandem lift capacity of 220 long tons
- 1 Gantry crane with lift capacity up to 600 tons
- 360,000 square feet of covered fabrication and shop area
- Two machine shops with three overhead cranes, 11 lathes, 6 milling machines, 4 grinders, 5 drill presses, planers, shapers, and lapping machines
- Full-service pipe and sheet metal shops
- Valve shop
- Electrical and electronic repair facility
- Structural fabrication shop
- Special barge to perform in-water rudder removal
- Ballast Water Treatment Plant

- Compressed air, electricity, garbage sterilization, natural gas, oxygen, potable water, river water, sewer disposal, steam, and telephone

2.4 Upland Investigations

Since 2000, the Port has completed facility-wide RI activities, including Phase I RI soil and groundwater investigations, Phase II RI groundwater monitoring well installation, four quarters of groundwater sampling, and five years of annual groundwater sampling. The results of these Phase I and Phase II RI investigations, as well as the 1998 investigations performed as part of the PSY sale to Shipyard Commerce Center LLC, are documented in a series of RI and groundwater monitoring reports (Bridgewater Group, 2000, 2001, 2002, 2003, 2004, 2005, 2006a, 2006b, 2007, and 2008).

The Port has also performed OU-specific investigation activities. At OU1, the Port completed sampling of former substations (Ash Creek, 2007a and 2007b), a Level I Scoping Ecological Risk Assessment (NewFields, 2008), surface soil sampling to support ecological risk screening (Ash Creek, 2010a), a Level II Screening Ecological Risk Assessment (Formation Environmental, 2011), and a Human Health Risk Assessment (Ash Creek, 2009).

The following sections summarize the scope and results of work performed relevant to the OU1 SCE. Soil sample locations are shown on Figures 2 through 6; grab groundwater sample locations are shown on Figure 10 in Appendix B; and monitoring well locations are shown on Figure 5 in Appendix C. Data relevant to the SCE are listed in Tables 1 and 2 in Appendix A; Tables 21 through 28 in Appendix B, and Tables 2 through 4 in Appendix C.

2.4.1 Ecological Level II Risk Assessment Sampling

In October 2009, 12 surface soil samples (designated SS-OU1-BWTP-01 through -12) were collected to support the Level II Ecological Risk Assessment. The samples were collected along the top of the riverbank adjacent to the BWTP. Samples were collected at a depth of 0 to 1 foot and analyzed for total petroleum hydrocarbons (TPH), metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and tributyltin (TBT). Results are presented in a technical memorandum (Ash Creek, 2010a). Data from this sampling are listed in Table 1 in Appendix A.

2.4.2 Riverbank Sampling

In August 2012, a visual reconnaissance of the OU1 riverbank was completed to identify potentially erodible soil (see further discussion in Section 4.3). Nineteen soil samples (OU1-RB1 through OU1-RB19) were collected from potentially erodible surface soil. The samples were analyzed for metals, PCBs, PAHs, and butyltins. Results were presented in a riverbank sampling report (Ash Creek, 2012). Data from this sampling are listed in Table 2 in Appendix A.

2.4.3 Groundwater Investigations

Groundwater data were collected during multiple investigations conducted between 2001 and 2007 as summarized in the following subsections.

2.4.3.1 Grab Groundwater Sampling

2001 Phase IA Remedial Investigation. Between January and February 2001, the Port completed 52 push-probe borings at the SIUF. Groundwater grab samples were collected from 20 borings located on OU1 (B-1 through 11, B-29 through B-41, B-43, B-44, and B-47 through B-51). The samples were analyzed for metals, butyltins, volatile organic compounds (VOCs), and PAHs. The results are presented in the *Phase IB Work Plan Addendum* (Bridgewater, 2001). Grab groundwater data from the RI are listed in Tables 21 through 28 in Appendix B. Figure 10 in Appendix B shows the sample locations.

2.4.3.2 Monitoring Well Sampling

In December 2001, the Port installed 11 monitoring wells at the SIUF (MW-1 through MW-11). Ten of the monitoring wells (MW-1 through MW-10) were installed on OU1. One year of quarterly sampling of the monitoring well network was conducted (Bridgewater, 2001 and 2002). For the quarterly monitoring, groundwater samples were analyzed for metals, TBT, VOCs, and PAHs. In addition, six of the monitoring wells were sampled annually for selected parameters through 2007. The shift from quarterly to annual sampling coincided with the implementation of low-flow sampling methods, as requested by DEQ, to reduce sample turbidity and provide more representative results. The most recent groundwater monitoring report discusses groundwater sampling (Bridgewater Group, 2008). Monitoring well data are listed in Tables 2 through 4 in Appendix C. Figure 5 in Appendix C shows the monitoring well locations.

2.5 Nearshore Sediment Data

Extensive sampling of sediments has been completed at the shipyard and Swan Island Lagoon. The results of the sampling are evaluated in detail in the Portland Harbor RI report.

3.0 Migration Pathways Evaluated

In accordance with the JSCS guidance, the approach to the SCE includes the identification of each known or potentially complete migration pathway to the river. Potential migration pathways are evaluated in this section. Potentially complete migration pathways are further evaluated in Sections 5 and 6.

3.1 Identification of Migration Pathways

Overwater Activities. The Port is not the owner or operator of OU1, so this SCE addresses only historical releases and pathways associated with historical releases. Therefore, the overwater pathway is not addressed in this SCE.

Storm Water Pathway. As stated above, this SCE addresses historical releases. Therefore, the storm water pathway is not addressed in this SCE.

Storm Water Conveyances as Preferential Groundwater Migration Pathway. This pathway is incomplete. As discussed in Section 2.1, the depth to groundwater ranges from 18 to 31 feet bgs at OU1 (see Table 1 in Appendix C). This range of variation is based on six years of water level monitoring at MW-1 through MW-10 over a broad range of Willamette River elevations. Records are limited, but it is likely that active and inactive storm water pipes are or were located at shallower depths (i.e., above the seasonal high water table). Therefore, this pathway is likely incomplete and is not further addressed in this SCE. This pathway will be further researched if necessary based on results of the groundwater pathway evaluation.

Riverbank Erosion Pathway. The riverbank may be subjected to erosive forces from river currents, wind waves, boat wakes, sheet flow, and storm water discharges. If erodible soil and chemical constituents are co-located in soil on the riverbank, these have the potential to migrate to the river or lagoon. The riverbank erosion pathway is carried forward for further evaluation.

Groundwater Pathway. Groundwater monitoring performed as part of the SIUF RI determined that groundwater beneath Swan Island flows either to the Willamette River or to Swan Island Lagoon. Constituents present in groundwater, if any, therefore have the potential to migrate to the river or lagoon. This pathway is carried forward for further evaluation.

3.2 Summary of Migration Pathways Evaluated

The riverbank erosion and groundwater pathways are carried forward for evaluation in this SCE. The other potential migration pathways are either incomplete or represent pathways for current activities that will be evaluated by others. Evaluation of the riverbank pathway includes potential for erosion of the riverbank (Section 4), screening of historical chemical data in riverbank soil (Section 5.2), and a weight-of-evidence evaluation of the potential for migration of chemicals to the river at concentrations above levels of concern (Section 6.1). Evaluation of the groundwater pathway includes screening of historical chemical data (Section 5.3) and a weight-of-evidence evaluation of the potential for migration of chemicals to the river at concentrations above levels of concern (Section 6.2).

4.0 Riverbank Erosion Evaluation

This section presents an analysis of the potential for erosion of the OU1 riverbank. The analysis included the following elements:

- Using historical aerial photographs to document changes in the riverbank location;
- Assessing the overall stability of the existing riverbank;
- Conducting a visual reconnaissance of the riverbank;
- Evaluating potential for surface soil erosion from runoff using an analytical erosion model; and
- Assessing potential for erosion of the bank from river action.

4.1 Evaluation of Aerial Photographs

Eight aerial photographs spanning the period from 1936 through 2008 were reviewed to evaluate changes in the location of the Swan Island riverbank at OU1. Copies of the aerial photographs are included in Appendix E. Because the OU1 riverbank is dominated by manmade structures, a quantitative evaluation of the riverbank location was not practicable. Instead, the OU1 riverbank was divided into five segments (corresponding to current conditions of the riverbank) and aerial photograph observations are discussed for each segment. The five segments are shown on Figure 2 and generally described as follows.

- River Side Docks – Marginal wharf fronting the Willamette River;
- BWTP – Riverbank generally adjacent to the BWTP;
- Dry Docks – Steel sheet pile vertical wall adjacent to the dry docks;
- Lagoon Side Docks – Marginal wharf fronting the Swan Island Lagoon; and
- Lagoon Bank – Riverbank fronting the Swan Island Lagoon.

For each of the five segments, the following presents a brief discussion of changes in the shoreline with references to aerial photographs in the appendix (by year in parentheses).

River Side Docks. The present shoreline in this area was constructed as an engineered slope for development of the airport (1936). The bank remained unchanged (1948 through 1969) until the 1970s when the marginal wharf was constructed (1978) that is currently present (1989 through 2008). As part of the SCE Addendum for OU2 (Ash Creek, 2011), this area was included in the aerial photograph evaluation of the riverbank and it was concluded that there were no substantive changes in the riverbank location throughout the history of the island.

BWTP. The present shoreline in this area was constructed in the late 1960s as an engineered bank for development of the BWTP (1969). The slope was modified slightly in the late 1970s during construction of the wharf along the Willamette River (1978). The riverbank was unchanged thereafter (1989 through 2008).

Dry Docks. This area was constructed in the 1940s and 1950s during construction of basins for the various dry docks at the shipyard (1948 and 1957). The shoreline consists of steel sheet pile cofferdams with no exposed soil. The riverbank is unchanged thereafter (1969 through 2008).

Lagoon Side Docks. The shoreline in this area was constructed as an engineered slope for development of the airport (1936). The slope remained unchanged until the marginal wharf was constructed for the war-time shipyard in 1942 (1948). The wharf is still present (1957 through 2008).

Lagoon Bank. The shoreline in this area was originally constructed as an engineered slope for development of the airport (1936). For the war-time shipyard, the bank was covered with a marginal wharf (1948). As part of that construction, some fill may have been placed on the bank (see 1969 aerial where top of bank appears to be toward the lagoon relative to 1936 aerial). The wharf was removed between 1957 and 1969. The riverbank is unchanged thereafter (1969 through 2008).

Summary of Aerial Photograph Review. The existing riverbank at OU1 consists of man-made slopes and structures constructed at various times between 1930 and the 1970s. Since construction of the bank as currently configured, there are no substantive changes to the riverbank visible in the aerial photographs.

4.2 Slope Stability Assessment

Stability of the riverbank at the OU1 was qualitatively assessed by comparing overall slope steepness to slope configurations generally considered susceptible to slope movement. The riverbank stability assessment was completed for each of the segments identified in Section 4.1.

River Side Docks. The marginal wharf present in this area was constructed in the late 1970s. The overall slope is approximately between 2H:1V and 2.5H:1V. During design and construction of this area, the stability of the slope was evaluated and found to be within the range of acceptable factors of safety (Dames & Moore, 1977 and 1978).

BWTP. The overall slope in this area varies from approximately 2.3H:1V to flatter than 3H:1V. Slopes of 2H:1V or flatter are common in developed areas throughout Portland Harbor and are generally not susceptible to slope movement.

Dry Docks. This area was constructed in the 1940s and 1950s during construction of basins for the various dry docks at the shipyard. The shoreline consists of steel sheet pile cofferdams with no exposed soil. These engineered structures are generally not susceptible to movement.

Lagoon Side Docks. The shoreline in this area was constructed in the 1920s as an engineered slope for development of the airport. A marginal wharf covering the slope was constructed for the war-time shipyard in 1942. There are remnants of a wooden bulkhead near the water line on the slope. The bulkhead appears to have decayed and is missing in most areas beneath the wharf. The slope steepness in this area is uncertain but is likely similar to the lagoon bank discussed below. The presence of the piling supporting the wharf provides some support for the surface materials on the slope. The steepness of the slope suggests that this area may be susceptible to slope movement, but because of the piling, less so than the lagoon bank to the east.

Lagoon Bank. The overall slope in this area varies from approximately 1H:1V to 1.8H:1V. Wooden bulkheads are present in this area to stabilize the slope. In some areas, the bulkheads have decayed and are missing. The areas where the bulkheads are missing correspond to steeper portions of the slope. Slopes steeper than 2H:1V may be susceptible to slope movement.

4.3 Riverbank Reconnaissance

On August 5, 2011, and again during sample collection in August 2012, Ash Creek completed visual reconnaissance of the OU1 riverbank. The entire length of the bank was observed, mapped, and photographed. Figures 3 through 6 show the results of the visual mapping, identifying geomorphic features, surface cover, and structures. Photographs documenting the observations are included in Appendix D. Photograph locations are shown on Figures 3 through 6.

The following discussion is organized by the areas defined in the aerial photograph review in Section 4.1.

River Side Docks. The river side dock area is shown on Figure 3. This area consists of a concrete wharf on concrete pilings overlying the riverbank. The riverbank under the wharf is characterized by near complete rip rap armoring from below the OLHW to a steel sheetpile bulkhead near the top of slope beneath the wharf. Between the OLHW and the sheetpile bulkhead is a series of erosion scarps. The locations, lengths, and heights of the scarps are shown on Figure 3, and the scarps are shown on Photographs 1 through 7. The erosion scarps are linear or slightly concave features running parallel to the riverbank. Exposed materials in most of the scarps consist of cemented sand, gravel, and rip rap. Four of the scarps (H, I, N, and X) are composed of loose material. Where the riverbank is covered with rip rap, there are no visible signs of erosion, demonstrating that rip rap armoring is effective in this area.

BWTP. This area is shown on Figure 4. This area is characterized by a uniform slope with rip rap on the lower portion and vegetation on the upper portion. Scattered along the riverbank at the transition between the rip rap and the vegetation are occasional erosion scarps or bare soil. The locations of the scarps are shown on Figure 4, and the features are shown on Photographs 8 through 15. The erosion scarps are linear or slightly concave features running parallel to the riverbank. In one area of the bank (feature AN; Photograph 15), small rills on the bank appear to be the result of overland flow from above the top of slope.

Dry Docks. The shoreline in this area consists of steel sheet pile bulkhead with rock buttresses in some areas. There is no exposed soil on the shoreline in this area.

Lagoon Side Docks. The lagoon side dock area is shown on Figure 5. This area is characterized by a concrete wharf on concrete pilings overlying the riverbank. The riverbank under the wharf is characterized by near complete rip rap armoring up to a steel sheetpile bulkhead. A wooden retaining wall was historically present along the riverbank below the OLHW. The locations of these features are shown on Figure 5, and the features are shown on Photographs 16 through 24. Where the riverbank is covered with rip rap, there was no observed indications of erosion, demonstrating that rip rap armoring has been effective.

Lagoon Bank. The lagoon bank area is shown on Figure 6. This area is characterized by a uniform slope with rip rap on the lower portion and dense vegetation on the upper portion. The lower portion of the slope is supported by wooden bulkheads running parallel to the top of slope. At scattered locations, the retaining wall has failed or erosion features were observed along the riverbank. The locations of these features are shown on Figure 6, and the features are shown on Photographs 25 through 31. Where the riverbank is covered with rip rap and is braced by an intact retaining wall, there was no observed indications of erosion, demonstrating that rip rap armoring and an intact wooden retaining wall are effective.

4.4 Analytical Erosion Model

Based on the site reconnaissance summarized in the prior section, riverbank potentially subject to sheet flow is present in the vicinity of the BWTP. The United States Department of Agriculture – Natural Resources Conservation Service (NRCS) has developed the Revised Universal Soil Loss Equation to estimate potential erosion of soil exposed to surface runoff. Software available from the NRCS was used to evaluate soil loss (RUSLE2) as part of the SCE for OU2 (Appendix D of Ash Creek, 2011). Input parameters – including geographic location, soil type, slope length, and slope steepness – are effectively the same at OU1 and OU2, so the OU2 results were used to assess potential erosion from surface runoff at OU1. For unvegetated soil, the model predicted on the order of 10 tons per acre per year of erosion. Assuming erosion would manifest primarily as rills covering a small percentage of the surface area (say 10 percent), rills one-half to one inch deep would be expected within one year. This is consistent with the observations of the exposed bare slopes in the vicinity of the BWTP.

4.5 Assessment of Potential for Erosion from River Action

Erosion from river action has two primary components: (1) bed shear resulting from the natural motion of the flowing water; and (2) wave action caused primarily from boat wakes.

Bed Shear. Bed shear was evaluated as part of the Portland Harbor RI. Figure 7 presents bed shear estimates along Swan Island adapted from modeling conducted as part of the Portland Harbor RI/FS Comprehensive Round 2 Report. The OU1 riverbank is located between River Miles 8 and 9 on the river and lagoon sides of Swan Island. Under both the high-flow and low-flow scenarios, bed shear is negligible along the OU1 riverbank except along the riverside docks. At the riverside docks, bed shear is low at the face of the docks, but the model did not calculate bed shear beneath the docks. Considering that bed shear decreases the farther up the bank and that the piling beneath the dock would reduce river velocity, bed shear beneath the docks would be less than predicted at the dock face. These results show that erosion from natural river flow is unlikely regardless of the soil and surface cover conditions.

Wave Action. In general, waves impacting unprotected riverbank may cause soil erosion depending on such factors as soil type, slope steepness, and wave height. The riverbank below ordinary high water is generally covered with rip rap. The vast majority of the riverbank above ordinary high water is covered with rip rap, dense grasses/vegetation, or engineered bulkheads. These surface covers are typically sufficient to withstand erosion from wave action. Portions of the riverbank, however, have visible erosion scarps near and above the OLHW consistent with erosion induced by wave action. When the river level is near the elevation of the erosion scarp (which is relatively infrequent because the scarps are above the OLHW), wave action could cause erosion of the scarp face.

4.6 Summary of Riverbank Erosion

Potential erosion was evaluated based on observation of historical aerial photographs, riverbank steepness, consideration of bed shear from river flow, and observation of erosional features on the riverbank. The following summarizes the overall potential for erosion of the riverbank at OU1.

River Side Docks. This area is characterized by a concrete wharf on concrete pilings overlying the riverbank. Scarps relatively high on the bank may be subject to erosion from wave action. Potential erosion events would be limited to periods of higher water so would be infrequent. There were no other indicators of potential erosion in this area.

BWTP. This area is characterized by a uniform slope with rip rap on the lower portion and vegetation on the upper portion. Scattered areas of small scarps, bare soil, and erosion around outfalls were observed in this area. These features may be subject to further erosion from wave action, sheet flow, and/or storm water discharges. Potential erosion events from wave action would be limited to periods of higher water so would be infrequent. There were no other indicators of potential erosion in this area.

Dry Docks. There is no potential for erosion in this area. The shoreline consists of steel sheet pile bulkhead with rock buttresses in some areas.

Lagoon Side Docks. This area is characterized by a concrete wharf on concrete pilings overlying the riverbank. Scarps relatively high on the bank may be subject to erosion from wave action. Potential erosion events would be limited to periods of higher water so would be infrequent. Where the wooden retaining wall is missing, the riverbank may be subject to slope movement. There were no other indicators of potential erosion in this area.

Lagoon Bank. This area is characterized by a uniform slope with rip rap on the lower portion and dense vegetation on the upper portion. The lower portion of the slope is supported by wooden bulkheads running parallel to the top of slope. In some areas of the slope, the wooden bulkhead has decayed and is missing. Where the bulkhead is missing, slopes are steeper and areas of bare soil were observed. These areas may be subject to erosion from wave action and slope movement. Where the wooden retaining wall is missing, the riverbank may be subject to slope movement. There were no other indicators of potential erosion in this area.

5.0 Upland Data Screening

5.1 Chemicals of Interest

The historical research conducted for the RI/FS Work Plan and Supplemental PA identified past activities and features that may be areas of concern as contaminant sources on OU1. The historical potential contaminant sources were investigated in the RI. Additionally, extensive sediment sampling around OU1 has been conducted and results are compiled in the Portland Harbor RI. Contaminants of interest (COI) were identified considering both nearshore sediment data and upland potential sources as discussed in the following sections.

5.1.1 Nearshore Sediment COI

Constituents present in river sediments adjacent to OU1 at “elevated” concentrations were retained as COI. Cleanup levels for in-water sediment have not yet been developed. Therefore, constituents exceeding U.S. Environmental Protection Agency (EPA) focused Preliminary Remediation Goals (PRGs) were used to identify COI. Constituents present in sediments adjacent to OU1 at concentrations above EPA focused PRGs are summarized as follows:

- Metals including copper, lead, mercury, nickel, and zinc;
- PCBs;
- Benzo(a)pyrene (and other PAHs as benzo(a)pyrene-equivalent);
- Semi-volatile organic compounds (SVOCs) including benzyl alcohol and 4-methylphenol;

- Pesticides including delta-hexachlorocyclohexane (delta-HCH), gamma-hexachlorocyclohexane (gamma-HCH or lindane), and DDT; and
- TBT.

5.1.2 Soil Data

Based on historical reviews, COI for upland investigations included metals, TPH, VOCs, PCBs, PAHs, and butyltins. The investigations described in Section 2.5 included analyses for each of these COI. Based on results of the RI and subsequent sampling, the DEQ identified metals, PAHs, PCBs, and TBT as COI for riverbank soil (Ash Creek, 2010b).

5.1.3 Groundwater Data

During the RI, grab groundwater samples were collected at the SIUF. The grab groundwater samples were analyzed for VOCs, PAHs, butyltins, and metals.

Ten monitoring wells (MW-1 through MW-10) were installed on OU1. Monitoring well samples were analyzed for COI based on detections in the grab groundwater sampling. The wells were sampled 4 to 11 times between 2001 and 2007. COI included metals, VOCs, PAHs, and TBT.

5.2 Riverbank Soil Data Screening

To evaluate the erosion pathway, data representative of soil with the potential to erode into the river were screened. Samples were collected from potentially erodible soil on the OU1 riverbank. Data from these samples were used to screen the riverbank erosion pathway. Figures 2 through 6 show the locations of the riverbank soil samples. Tables 1 and 2 in Appendix A present the soil data screened for the riverbank erosion pathway.

Results of the data screening are summarized below for each COI group. For the data screening, results are compared to the JSCS screening level values (SLVs). For each result, the ratio between the detected concentration and the SLV is defined as the enrichment ratio (ER). An ER of one or less indicates that the detected concentration did not exceed the SLV and it is presumed that there is not a source control concern. As described in the JSCS Guidance, an ER greater than one does not necessarily indicate the upland source of contamination poses an unacceptable risk to human or ecological receptors. The actual risk that a COI poses to the Willamette River is evaluated using the weight-of-evidence approach presented in Section 6.

Metals. Ten metals were analyzed in 31 riverbank soil samples, and three additional metals were analyzed in 19 riverbank soil samples. The following summarizes the results of the screening.

- Beryllium and thallium do not have JSCS SLVs.
- Antimony, selenium, and silver were not detected above SLVs.
- Chromium, nickel, and zinc were detected above SLVs in two to three out of 31 samples at maximum ERs ranging from 2 to 6. Average ERs were 0.6 or less.
- Cadmium was detected in 19 out of 31 samples at a maximum ER of 6 and an average ER of 1.9.
- Arsenic and copper were detected above SLVs in six to seven out of 31 samples at maximum ERs ranging from 56 to 120. Average ERs ranged from 3 to 5.
- Lead and mercury were detected above SLVs in 20 to 24 out of 31 samples at maximum ERs ranging from 44 to 1,200. Average ERs ranged from 3 to 41.

Metals were detected with an ER of greater than 10 only in sample OU1-RB-2. Excluding that sample, the maximum ER for metals was nine (lead in sample OU1-RB-19) and the highest relative average ER was 1.9 for lead.

PAHs. Thirty-one samples were analyzed for PAHs. The following summarizes the results of the screening.

- Two of the analyzed PAHs do not have JSCS SLVs.
- Seven PAHs were not detected above the SLV.
- Seven PAHs were detected above SLVs in one out of 31 samples at maximum ERs ranging from 1.2 to 4. Average ERs were 0.2 or less.
- Two PAHs (benzo(g,h,i)perylene and indeno(1,2,3-cd)pyrene) were detected above SLVs in two to five out of 31 samples at maximum ERs ranging from 21 to 61. Average ERs ranged from 0.9 to 2.6.

PAHs were detected with an ER of greater than 10 only in sample OU1-RB-2. Excluding that sample, PAHs were detected above the SLV in only four of 30 samples with a maximum ER of three and an average ER of less than one.

PCBs. Thirty-one samples were analyzed for PCBs. SLVs are available for Aroclors 1016, 1248, 1254, and 1260 and for total PCBs. The following summarizes the results of the screening.

- Aroclors 1016 and 1254 were not detected above the SLVs.
- Aroclor 1248 was detected above the SLV in one out of 31 samples at an ER of 19. The average ER was 0.6.
- Aroclor 1260 was detected above the SLV in eight out of 31 samples at a maximum ER of 3. The average ER was 0.7.

- Total PCBs were detected above the SLV in 27 out of 31 samples at a maximum ER of 72,000. The average ER was 2,700.

Aroclors 1248, 1254, and 1260 were detected at least once. Aroclor 1254 was not detected above its SLV. Aroclor 1248 was detected only once, at sample location OU1-RB-2. Excluding that sample location, the maximum ER for individual Aroclors is 3 (Aroclor 1260 only, in samples collected near the BWTP). Additionally, excluding sample OU1-RB-2, the higher relative total PCB ERs were from samples collected near the BWTP. Near the BWTP, total PCB ERs range from 110 to 1,600. Outside the BWTP area (and excluding OU1-RB-2), total PCB ERs range from not detected to 390, and there does not appear to be a pattern to the PCB distribution.

TBT. TBT was detected above the SLV in 25 out of 31 samples at a maximum ER of 1,700. The average ER was 180. The higher relative concentrations of TBT were detected in samples near the BWTP. Outside of that area, only one sample had an ER greater than 10: OU1-RB-1 with an ER of 25. The remainder of the samples ranged from TBT not detected to an ER of only seven.

Soil Summary. Riverbank soils contain metals, PAHs, PCBs, and TBT at concentrations above their SLVs. The following summarizes the distribution of COI in riverbank soil organized by the areas defined in the aerial photograph review in Section 4.1.

- River Side Docks. Metals, total PCBs, and TBT were detected at least once above SLVs. Except for total PCBs, ERs were less than 10. Total PCBs ranged from not detected to an ER of 380.
- BWTP. Metals, total PCBs, PAHs, and TBT were detected at least once above SLVs. Except for total PCBs and TBT, ERs were less than 5. Total PCB ERs range from 110 to 1,600. TBT ERs range from 2 to 1,700.
- Dry Docks. There is no exposed soil in this area so no sampling was completed.
- Lagoon Side Docks. Metals, total PCBs, PAHs, and TBT were detected at least once above SLVs. Except for total PCBs, ERs were less than 10. Total PCBs ranged from not detected to an ER of 290.
- Lagoon Bank. Metals, PCBs, PAHs, and TBT were detected at least once above SLVs. Sample location OU1-RB-2 contains the relatively higher concentrations of COI. Excluding that location, PAHs and metals have ERs of six or less; TBT has an ER of one or less in three of four samples and an ER of 25 in the fourth sample; total PCBs range from not detected to an ER of 390. At sample location OU1-RB-2, ERs exceed 1,000 for mercury and total PCBs; exceed 100 for arsenic; and exceed 10 for Aroclor 1248, copper, lead, benzo(g,h,i)perylene, and indeno(1,2,3-cd)pyrene.

5.3 Groundwater Data Screening

In this section, groundwater monitoring well data (used as a surrogate for groundwater potentially entering surface water) are screened to assess groundwater as a potential source to sediments and surface water. Figure 5 in Appendix C shows the locations of monitoring wells at OU1. Tables 2 through 4 in Appendix C present the groundwater data. Data sets used to screen COI in groundwater were determined as follows.

- Only monitoring well sample results were used to screen COI in groundwater. Grab groundwater samples result in greater turbidity than naturally present in groundwater. As a result, metals and semi-volatiles that have a greater affinity for solids than liquids will be biased high in these samples.
- Only data from monitoring wells located near the shoreline were used to screen COI in groundwater. Monitoring wells included in the dataset were MW-1, MW-2, MW-3, MW-5, MW-6, MW-7, MW-8, and MW-10.
- Samples collected prior to 2003 were collected using bailers (as opposed to current practice using low-flow techniques). These samples can have relatively higher turbidity concentrations that are an artifact of the sampling technique and not representative of actual groundwater conditions. For total metals analyses, only data collected since 2003 were included in the groundwater COPC screening. SVOCs, if present, tend to adsorb to solids, so results may be biased high for samples with greater turbidity. For organic compounds, the entire data set was used for initial screening. However, where detected, further screening was conducted using data collected since 2003.

For the monitoring well sample data set, metals, PAHs, and VOCs were detected at least once above JSCS SLVs. Results of the data screening are summarized below for each of these COI groups.

Again, an ER greater than one does not necessarily indicate the upland source of contamination poses an unacceptable risk to human or ecological receptors. The actual risk that a COI poses to the Willamette River is evaluated using the weight-of-evidence approach presented in Section 6.

Metals. For total metals analyses, arsenic, cadmium, copper, and nickel were detected at concentrations exceeding groundwater SLVs. For dissolved metals, arsenic, copper, lead, and nickel were detected above SLVs. Except for arsenic, metals exceeded the respective SLVs by a factor of 2.2 or less. Arsenic exceeded the SLV in 70 and 90 percent of the samples (for total and dissolved metals, respectively) at up to 370 times the SLV. Arsenic was detected above the SLV in each monitoring well except MW-6. Other metals detected above SLVs were in monitoring wells MW-1, MW-2, MW-3, MW-6, and MW-7. Except for arsenic, the most recent rounds of sampling are generally below SLVs.

PAHs. PAHs were relatively infrequently detected (ranging from 2 to 36 percent of samples analyzed). Eleven of the 14 PAH COI were detected at least once above SLVs at exceedance factors ranging from 1.7 to 7.2 and frequencies of 2 to 11 percent. Samples exceeding SLVs were collected from MW-1 and MW-8.

A majority of the samples that exceeded SLVs were collected prior to implementation of low-flow techniques. Additionally, for 25 of the 28 exceedances, at least five rounds of sampling occurred after the exceedance with concentrations below SLVs. For the remaining three exceedances, one to three rounds of sampling occurred after the exceedance with concentrations below SLVs.

VOCs. Of the VOC COI, only TCE was detected in samples from monitoring wells, at a frequency of 6 percent. TCE was not detected above the SLV.

Groundwater Summary. Metals and PAHs were detected in groundwater above SLVs. Except for arsenic, metals exceeded the SLVs in groundwater by a factor of 2.2 or less, and the most recent rounds of sampling are generally less than the SLVs. PAHs exceeded SLVs by a factor of 7 or less, and the most recent samples collected from monitoring wells had concentrations of PAHs less than the SLVs.

6.0 Source Control Evaluation

This section presents a detailed evaluation of potential sources to the Willamette River from OU1. For the COI and each potentially complete pathway to the river, a weight-of-evidence evaluation is presented below based on applicable site-specific factors listed in Sections 5.1.2 and 5.2 of the JSCS guidance.

6.1 Riverbank Erosion Pathway

Section 4 presented a detailed evaluation of the potential for erosion of the OU1 riverbank, as summarized in Section 4.6. Riverbank soil data were screened in Section 5.2. Combining results from the erosion evaluation and the soil screening, the following presents the weight-of-evidence evaluation of the riverbank erosion pathway.

6.1.1 River Side Docks

There was a single line of evidence of erosion beneath the wharf structure. The riverbank is covered with rip rap, but high on the slope were observed erosion scarps. These scarps are normally above the river level and are protected from overland flow from the overlying wharf. These scarps could be subjected to potential wave action during infrequent high water levels. Five soil samples were collected from observed historical erosion features. One to four metals (cadmium, copper, lead, and mercury) were detected at least once above SLVs in each sample, but ERs were 5 or less in four of the samples, and the maximum ER was 8, for mercury. TBT was detected in two of the five samples, but the maximum ER was less than 2. PCBs were not detected in two of the five samples. Where detected, the ER for total PCBs ranged from 12 to 380. Cadmium, lead, mercury, PCBs, and TBT are bioaccumulative COI. Nickel, TBT, and PCBs were detected above EPA focused PRGs in sediments adjacent to this area. PCBs exceeded only the Background Hilltop PRG. The inconsistent soil/sediment results – nickel above the PRG in sediments but below default background in soil; several metals above SLVs in soil but not present above PRGs in sediment; TBT above PRGs in sediment but not detected in three of five soil samples and with a maximum ER of only 1.7 – suggest that the presence of COI in sediments is not related to erosion of soil from the riverbank. Based on the following multiple lines of evidence, the riverbank in this area is a low priority site and no further source control efforts are recommended:

- The majority of the riverbank is armored and it is covered with a wharf;
- Evidence of erosion is limited to high on the riverbank that river levels achieve only infrequently;
- Except for total PCBs, maximum ERs are 8 or less;
- PCB Aroclors did not exceed SLVs;
- Only total PCBs exceeded the very low bioaccumulative PRG by a factor of greater than 100 in two of five samples; and
- Consideration of soil and adjacent sediment data suggest that soil erosion is not a source of COI in sediment.

6.1.2 BWTP

There was a single line of evidence of erosion of the riverbank along the BWTP. The riverbank is mostly covered with rip rap and vegetation, but at the transition from the rip rap to vegetation were observed scattered erosion scarps and occasional areas of bare soil. These scarps are normally above the river level. The areas of bare soil are subjected to some overland flow. The scarps could be subjected to potential wave action during infrequent high water levels and the bare soil shows signs of limited erosion from overland flow. Nineteen soil samples were collected from observed historical erosion features and the riverbank in this area. Metals (arsenic, cadmium, copper, lead, mercury, and zinc), Aroclor 1260, total PCBs, PAHs, and TBT were detected at least once above SLVs. Except for total PCBs and TBT, ERs were less than five. Total PCB ERs ranged from 110 to 1,600. TBT ERs ranged from 2 to 1,700. Arsenic, cadmium, lead, mercury, PCBs, and TBT are bioaccumulative COI. Metals (copper, lead, nickel, and zinc), PCBs, benzo(a)pyrene, TBT, DDT, and SVOCs were detected above EPA focused PRGs in sediments adjacent to this area. Given that an erosion pathway to the river may be present and the presence of TBT and PCBs in soil with ERs greater than 1,000, the riverbank in this area is a medium priority. The areas of erosion would typically be addressed by restoring the rip rap and/or vegetation in areas where scarps or bare soil are present. Although most of these features are above the OLHW, in many cases, a portion of the work would be below the OLHW to create a stable base for the repairs. Given that work below the OLHW would be required and that these areas would be only infrequently subject to erosion, addressing these areas can be incorporated into the final remedy for the in-water cleanup.

6.1.3 Dry Docks

There is no potential for erosion in this area. The shoreline consists of steel sheet pile bulkhead with rock buttresses in some areas. Because there is no current or reasonably likely complete contaminant pathway to the river, the dry dock area is excluded from source control.

6.1.4 Lagoon Side Docks

There were limited lines of evidence of erosion beneath the wharf structure. The riverbank is covered with rip rap nearly throughout. One erosion scarp (length approximately 25 feet) was observed above a 36-inch outfall pipe, and one area of steep slope was observed. The length of the riverbank in this area is approximately 2,100 feet. Two soil samples were collected from this area: one from the erosion scarp and one from an area where black grit was observed. Metals (arsenic, cadmium, copper, chromium, lead, nickel, and zinc), total PCBs, indeno(1,2,3-cd)pyrene, and TBT were detected at least once above SLVs. Except for total PCBs, ERs were less than nine. PCBs were detected in one of the two samples, and the total PCB ER in the one sample was 290. Arsenic, cadmium, lead, PCBs, and TBT are bioaccumulative COI. Metals (copper, lead, nickel, and zinc), PCBs, benzo(a)pyrene, TBT, and pesticides were detected above EPA focused PRGs in sediments adjacent to this area. Based on the following multiple lines of evidence, the riverbank in this area is a low priority site and no further source control efforts are recommended:

- The majority of the riverbank is armored and it is covered with a wharf;
- Evidence of erosion is limited to approximately 100 feet of the 2,100-foot-long riverbank;
- Except for PCBs, maximum ERs are nine or less;
- PCB Aroclors did not exceed SLVs; and
- Only total PCBs exceeded the very low bioaccumulative PRG by a factor of 290 in one of two samples.

6.1.5 Lagoon Bank

This area is characterized by a uniform slope with rip rap on the lower portion and dense vegetation on the upper portion. The lower portion of the slope is supported by wooden bulkheads running parallel to the top of slope. In some areas of the riverbank, the wooden bulkhead has decayed and is missing. Where the bulkhead is missing, slopes are steeper and areas of bare soil and scarps were observed. These areas may be subject to erosion from wave action and slope movement. Five soil samples were collected from erosion features in this area. Metals (arsenic, cadmium, copper, chromium, lead, mercury, and zinc), Aroclor 1248, total PCBs, PAHs, and TBT were detected at least once above SLVs. Sample location OU1-RB-2 contains the relatively higher concentrations of COI in this area. Excluding that location, PAHs and metals have ERs of six or less; TBT has an ER of one or less in three of four samples and an ER of 25 in the fourth sample; total PCBs range from not detected to an ER of 390. At sample location OU1-RB-2, ERs exceed 1,000 for mercury and total PCBs; exceed 100 for arsenic; and exceed 10 for Aroclor 1248, copper, lead, benzo(g,h,i)perylene, and indeno(1,2,3-cd)pyrene. Arsenic, cadmium, lead, mercury, fluoranthene, pyrene, PCBs, and TBT are bioaccumulative COI. Metals (copper and zinc), PCBs, benzo(a)pyrene, TBT, 4-methylphenol, and lindane were detected above EPA focused PRGs in sediments adjacent to this area. Except for the area of OU1-RB-2, the lagoon area riverbank has relatively low ERs so is a low priority and no further source control efforts are recommended. In the vicinity of OU1-RB-2, there may be an erosion pathway to the river and mercury and PCBs are present in soil with ERs greater than 1,000, so the riverbank in the vicinity of sample OU1-RB-2 is a medium priority. This area of erosion would typically be addressed by restoring the rip rap in the area of the scarp/bare soil. At least a portion of this work would be below the OLHW to create a stable base for the repairs. Given that work below the OLHW would be required and that this area is relatively small, addressing this area can be incorporated into the final remedy for the in-water cleanup.

6.2 Groundwater Pathway

The screening of the groundwater monitoring well samples (Section 5.3) identified metals and PAHs above JSCS groundwater/surface water/storm water SLVs. Based on the data screening and the weight-of-evidence evaluation below, the groundwater pathway from OU1 is a low priority for source control and no further source control efforts are recommended.

- Metals screening demonstrates that concentrations in groundwater are near or less than screening levels and/or consistent with background concentrations.
    - Except for arsenic, metals exceeded SLVs by factors of 2.2 or less, and the more recent sampling results have lower concentrations relative to prior sampling events.
    - The arsenic concentrations detected in groundwater on OU1 represent background concentrations based on the following.
        - Arsenic in soil is within the background range of arsenic. Only three samples out of over 100 samples exceeded the default background concentration of 7 milligrams per kilogram (mg/kg), with the maximum detected concentration of 16 mg/kg.
        - Detected concentrations of arsenic in groundwater are within the range of natural concentrations of arsenic in groundwater within the Willamette Basin. A report prepared by the United States Geological Survey (Hinkle and Polette, 1999) found concentrations of arsenic within the Willamette Basin to range from <1 to 2,000 micrograms per liter (μg/L), with 22 percent of the samples greater than 10 μg/L. The detected concentrations of arsenic for riverbank wells within OU1 since 2003 ranged from <0.5 to 16 μg/L.
        - The range of detected concentrations of arsenic in groundwater at OU1 is consistent with concentrations detected at other waterfront sites. For example, the following compares

the ranges of detected concentrations of arsenic at OU1 with OU2 and Terminal 4 Slip 1 (T4S1).

Data Set	Concentration Range in µg/L		
	SIUF OU1	SIUF OU2	T4S1
Total As in MWs	<0.5 – 16	<0.5 – 17	<0.02 – 15

- Screening of organic compounds in groundwater showed that only PAHs were detected above SLVs. Evaluation of the data demonstrates that representative concentrations in groundwater are less than screening levels.
    - PAHs were infrequently detected (rates of 2 to 36 percent);
    - SLV exceedances were 7 or less;
    - SLVs were exceeded at frequencies of 2 to 11 percent;
    - For the most recent sampling events, SLVs were not exceeded (at least five rounds below SLVs for 25 of the 28 exceedance events).

7.0 Findings and Conclusions

Existing and potential sources to the Willamette River at OU1 were identified and characterized. Upland soil and groundwater sampling were performed under DEQ-approved work plans. Riverbank soil samples were collected from areas identified as having the potential for erosion. Riverbank erosion and groundwater were identified as potential pathways for contaminant transport to the Willamette River (storm water and overwater activities are being addressed by others). Each pathway was evaluated with the following results.

Riverbank Erosion. The OU1 riverbank is approximately 6,800 feet long. Approximately 5,700 feet of the riverbank was determined to be either excluded from need for source control or to be low priority for source control. Areas were excluded because there is no current or reasonably likely complete contaminant pathway to the river. Areas were determined to be low priority because multiple lines of evidence supported that there is a low potential for that area to contaminate the river. Two areas totaling 1,100 feet in length were found to be medium priority, summarized as follows.

- BWTP – This area has visual evidence of erosion, and riverbank soil contains total PCBs and TBT at ERs up to 1,600 and 1,700, respectively.
- Vicinity of Sample OU2-RB-2 – This area has a visible erosion scarp and riverbank soil contains total PCBs, Aroclor 1248, mercury, arsenic, copper, lead, indeno(1,2,3-cd)pyrene, and benzo(g,h,i)perylene at ERs up to 72,000, 19, 1,200, 120, 56, 44, 61, and 21, respectively.

Based on relatively limited areas needing source control and the need for at least a portion of the work to be below the OLHW, it is recommended that source control for the medium priority riverbank areas be incorporated into the final remedy for the in-water cleanup.

Groundwater. The groundwater pathway from OU1 is a low priority for source control and no further source control efforts are recommended. The groundwater pathway conclusion is based on the following:

- Metals detected in groundwater nearest the river are consistent with background concentrations and/or exceed the SLV by a factor of two or less; and
- Concentrations of organic compounds from representative groundwater samples are below detection limits and/or below SLVs.

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NOTE: Base map prepared from USGS 7.5-minute quadrangles as provided by Topozone. (1990)

0 2,000 4,000

Approximate Scale in Feet

N

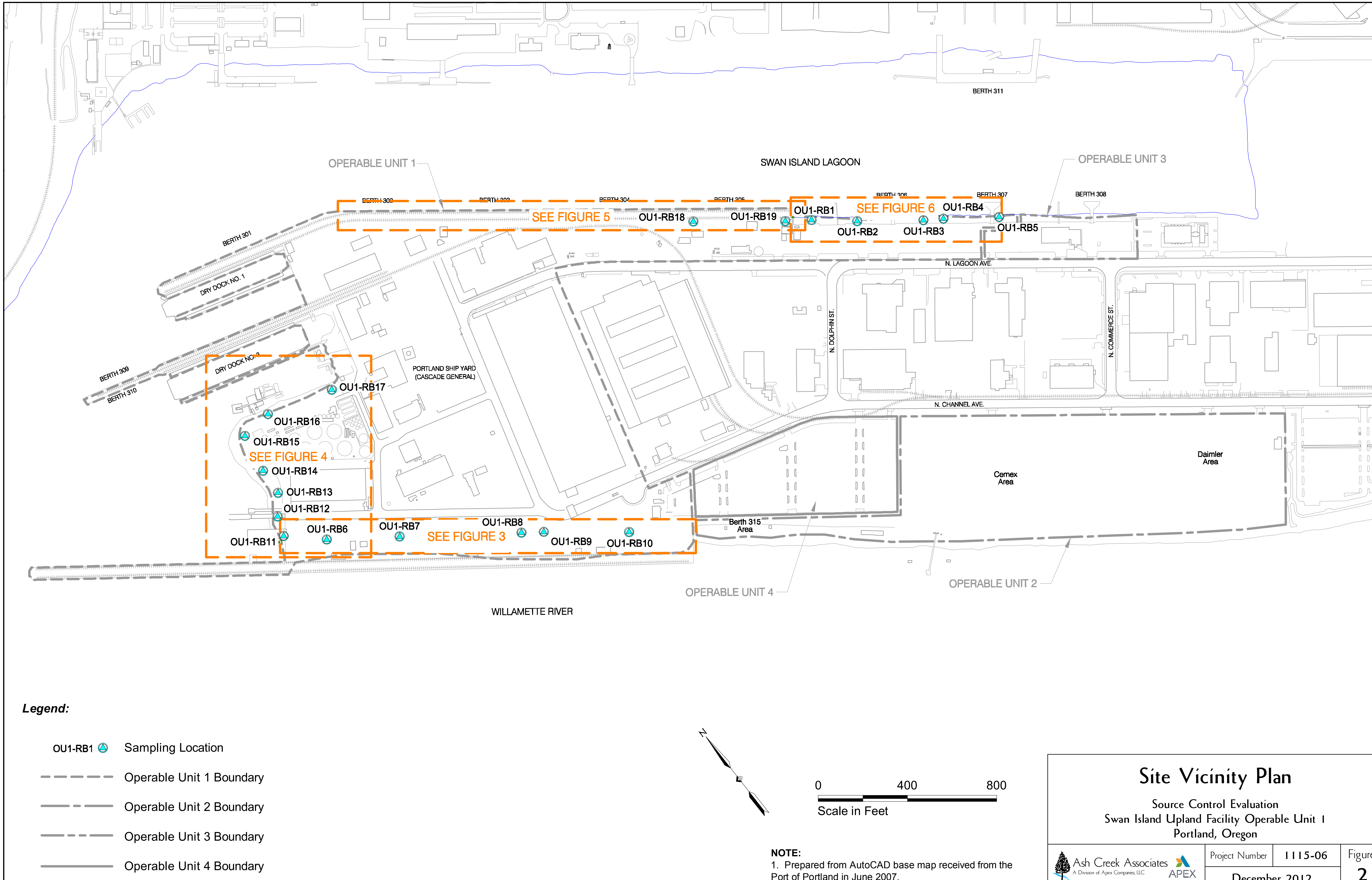
Facility Location Map

Source Control Evaluation

Swan Island Upland Facility Operable Unit 1

Portland, Oregon

Ash Creek Associates A Division of Apex Companies, LLC APEX	Project Number	1115-06	Figure 1
	December 2012		



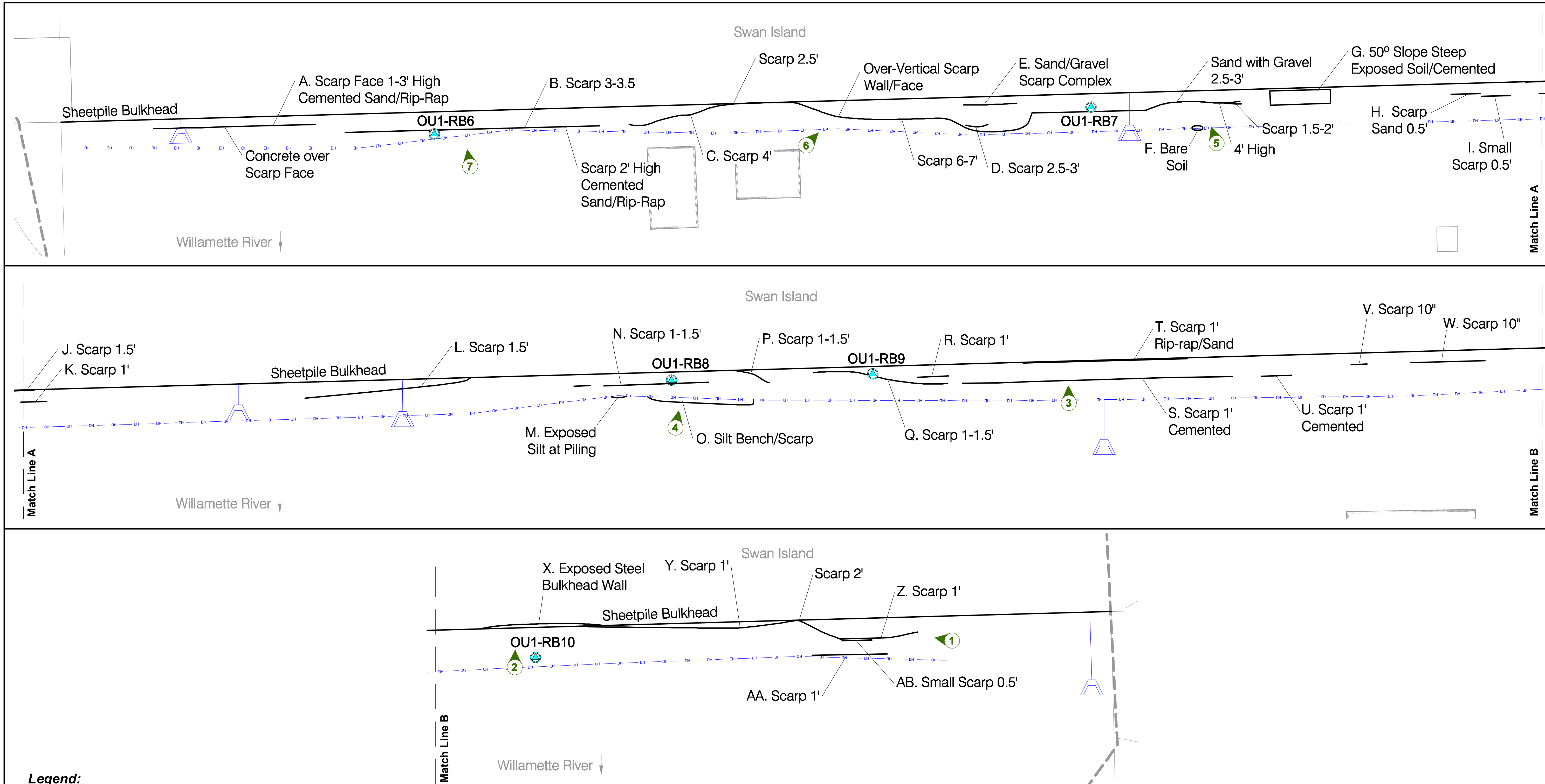
NOTE:
1. Prepared from AutoCAD base map received from the Port of Portland in June 2007.

Site Vicinity Plan

Source Control Evaluation
Swan Island Upland Facility Operable Unit 1
Portland, Oregon

Ash Creek Associates
A Division of Apex Companies, LLC
APEX

Project Number	1115-06	Figure
December 2012		2



Legend:

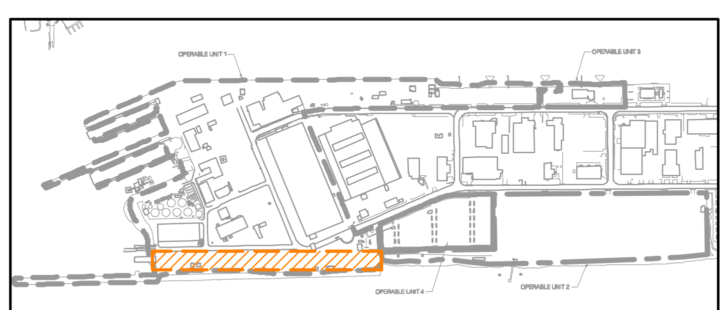
OU1-RB6 Riverbank Soil Sampling Location

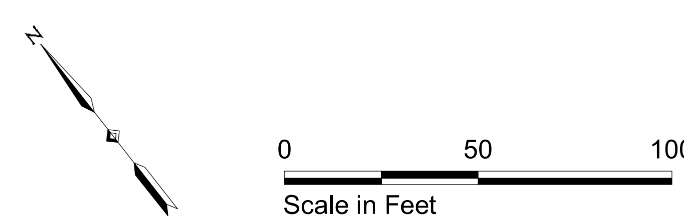
Photograph Location, Number, and Direction Taken

Ordinary High Water Line (Approximate)

Approximate Outfall Location

Operable Unit 1 Boundary





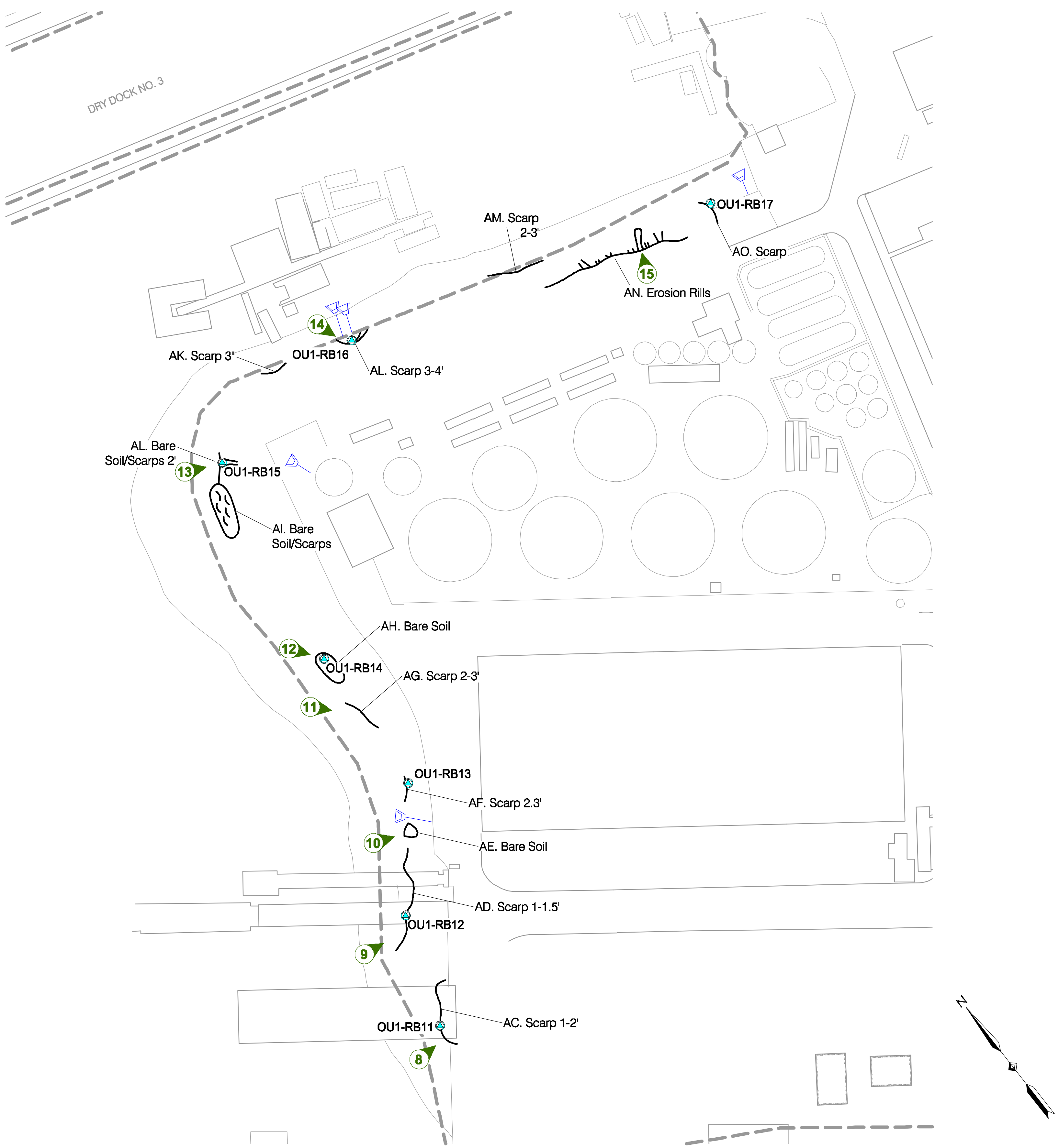
NOTE:
1. Prepared from AutoCAD base map received from the Port of Portland in June 2007.

River Side Docks

Source Control Evaluation
Swan Island Upland Facility Operable Unit 1
Portland, Oregon

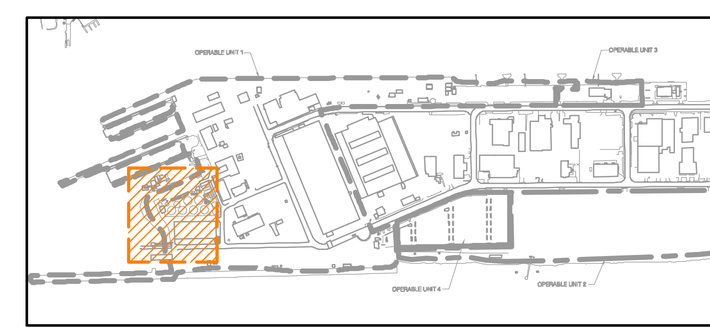
Ash Creek Associates, A Division of Apex Companies, LLC — APEX

Project Number	1115-06	Figure
December 2012		3



Legend:

- OU1-RB6 — Riverbank Soil Sampling Location
- 25 — Photograph Location, Number, and Direction Taken
- Approximate Outfall Location
- Operable Unit 1 Boundary



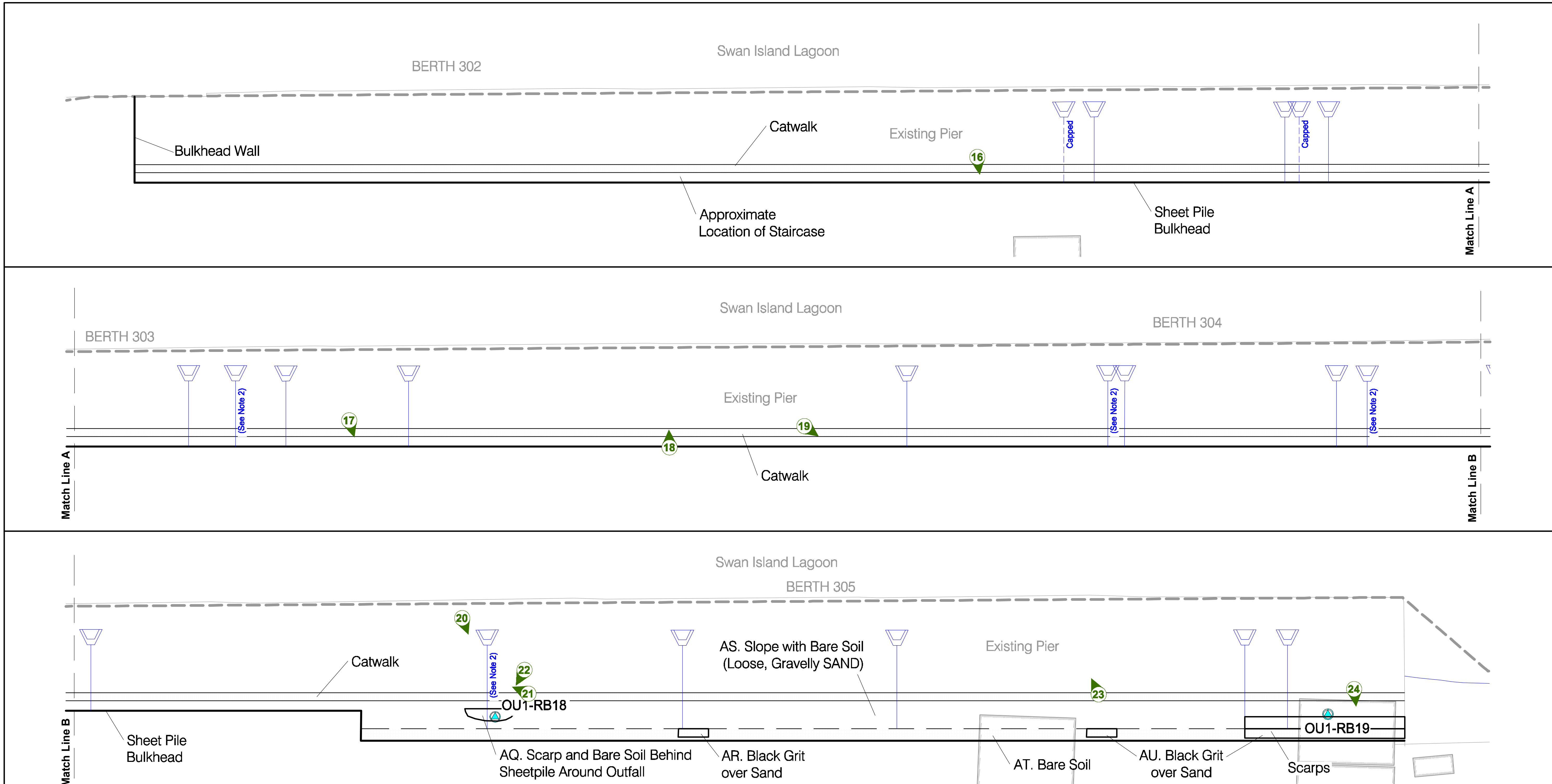
NOTE:
1. Prepared from AutoCAD base map received from the Port of Portland in June 2007.

Vicinity of BWTP

Source Control Evaluation
Swan Island Upland Facility Operable Unit 1
Portland, Oregon

Ash Creek Associates
A Division of Apex Companies, LLC
APEX

Project Number	1115-06	Figure
December 2012		4



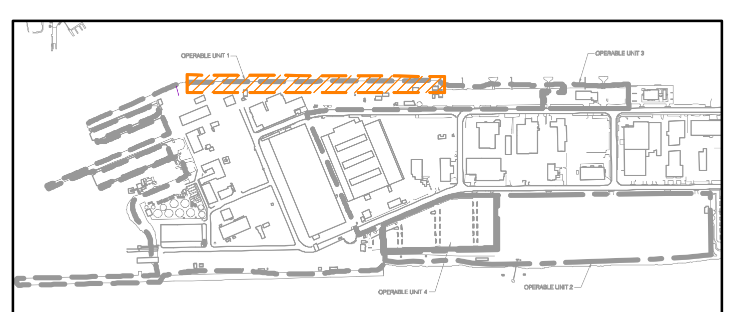
Legend:

OU1-RB18 Riverbank Soil Sampling Location

25 Photograph Location, Number, and Direction Taken

Approximate Outfall Location

Operable Unit 1 Boundary



N

0 50 100

Scale in Feet

NOTE:
1. Prepared from AutoCAD base map received from the Port of Portland in June 2007.
2. Outfall pipe needs repair (e.g., separated/fallen Segment allowing water to discharge further upslope).

Lagoon Side Docks

Source Control Evaluation
Swan Island Upland Facility Operable Unit 1
Portland, Oregon

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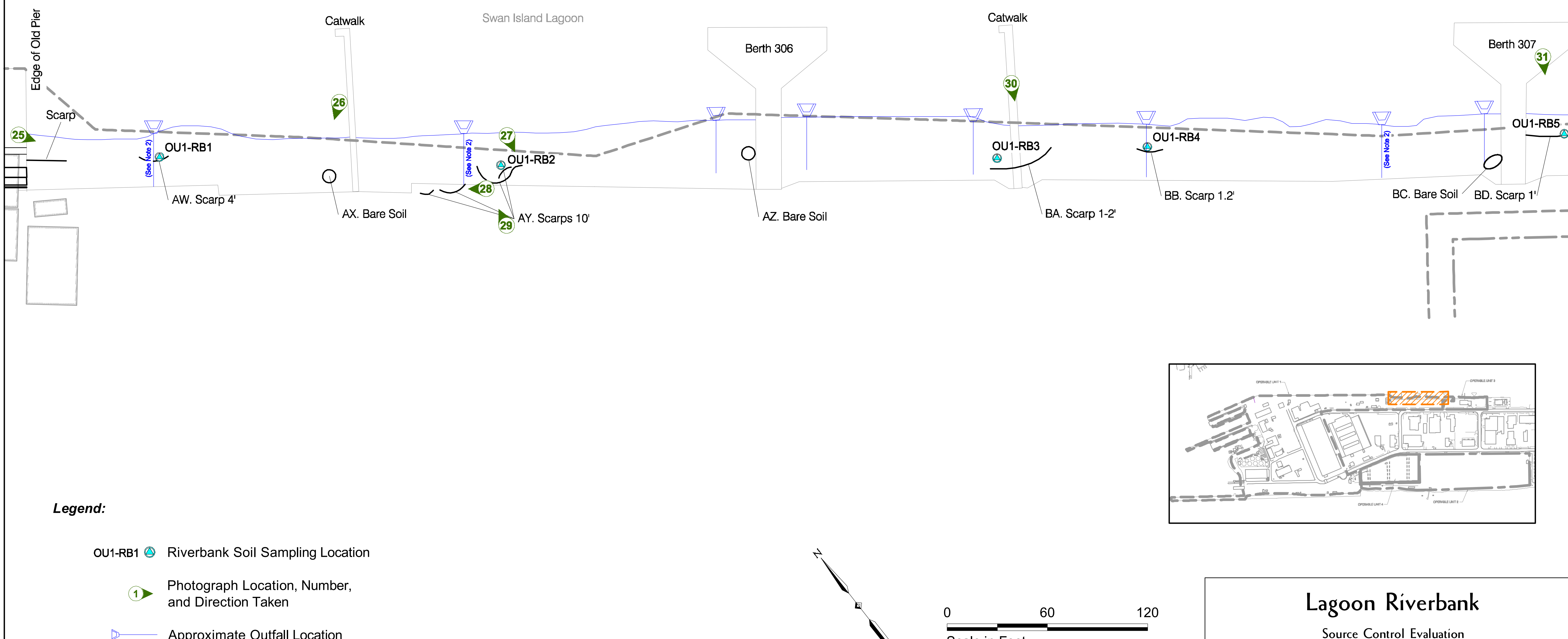

Legend:

OU1-RB1 Riverbank Soil Sampling Location

1 Photograph Location, Number, and Direction Taken

Approximate Outfall Location

Operable Unit 1 Boundary

Operable Unit 3 Boundary

NOTE:
1. Prepared from AutoCAD base map received from the Port of Portland in June 2007.
2. Outfall pipe needs repair (e.g., separated/fallen Segment allowing water to discharge further upslope).

Lagoon Riverbank

Source Control Evaluation
Swan Island Upland Facility Operable Unit 1
Portland, Oregon

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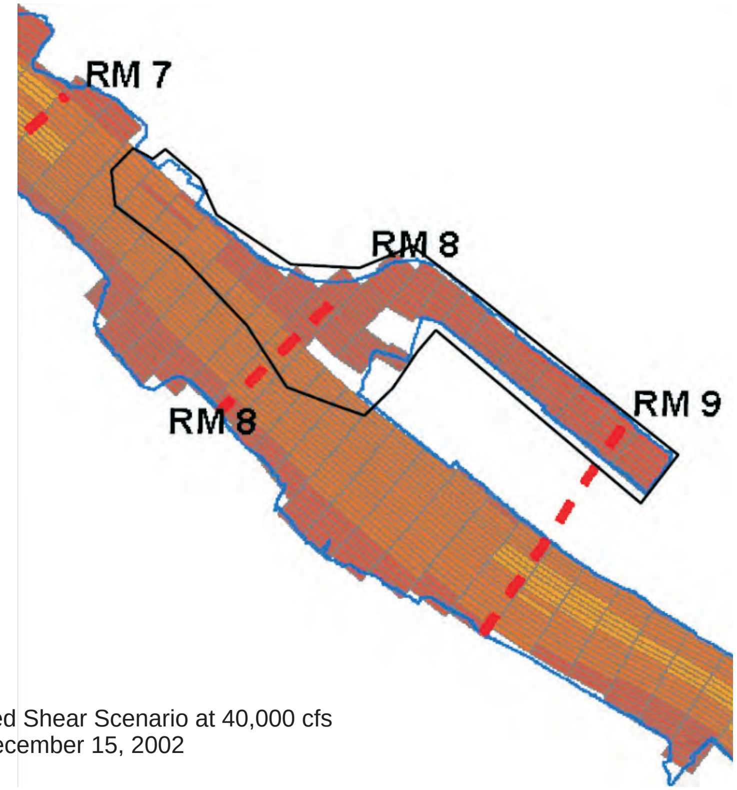
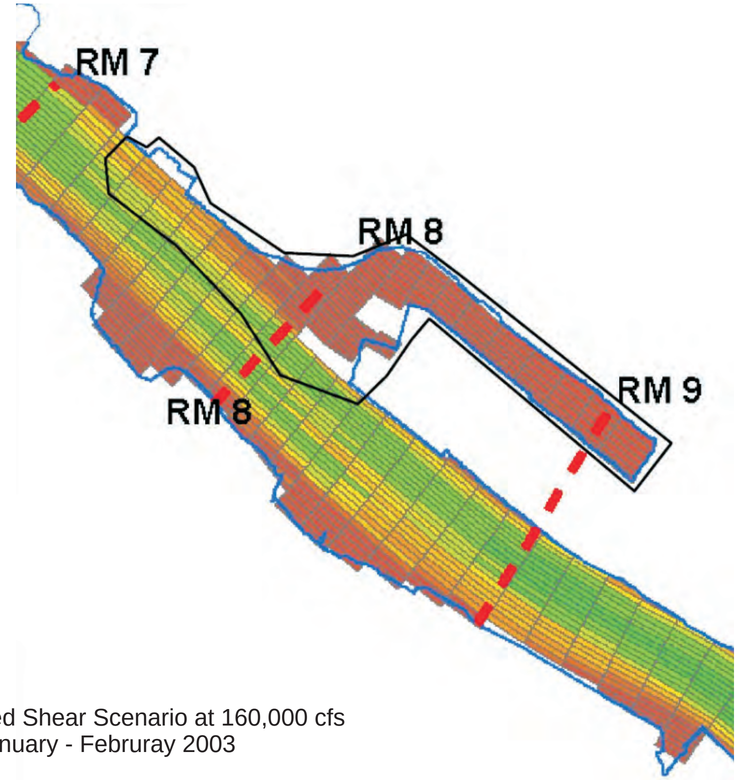
Project Number 1115-06
December 2012
Figure 6



Bed Shear Scenario at 40,000 cfs
December 15, 2002



Bed Shear Scenario at 160,000 cfs
January - Februray 2003

N

0 1,500 3,000
Approximate Scale in Feet

Projected Bed Shear from Hydromodel

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Swan Island Upland Facility Operable Unit 1
Portland, Oregon

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Note: Figure adapted from Map 3.1-8 of 8-29-11 Portland Harbor RI submitted to EPA.